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**(54) Title:** METHOD AND ARRANGEMENT FOR DYNAMIC SIGNALLING
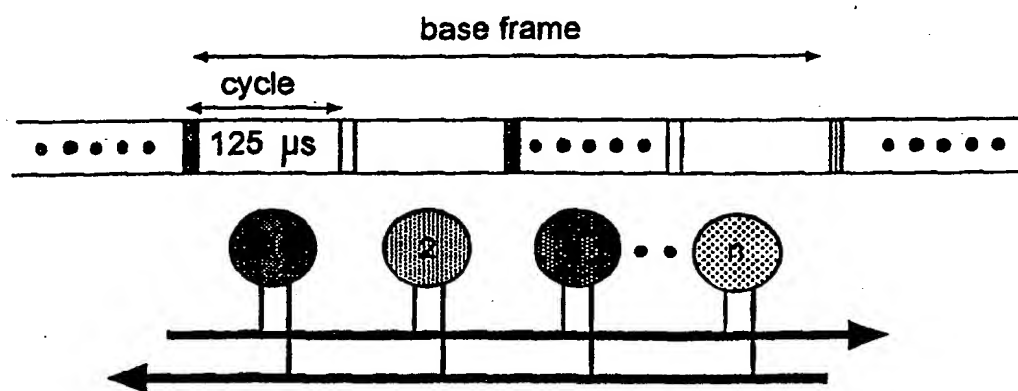


**(57) Abstract**

The present invention relates to a method and an arrangement for dynamic signalling in a network, such as a Dynamic Synchronous Transfer Mode (DTM) network. The network's bandwidth is divided into cycles, which in turn are divided into control slots for control signalling and data slots for transferring data. Preferably, each or certain nodes have a node controller, which control the access to slots. According to the invention data slots are converted into control slots, called dynamic control slots, or control slots are converted into data slots in order to change the signalling capacity of a node. The dynamic control slots may be used for point-to-point, multicast or broadcast signalling.

# METHOD AND ARRANGEMENT FOR DYNAMIC SIGNALLING

## Technical field of invention

The present invention relates to a method and an
arrangement for dynamic signalling in a time multiplexed
network, such as a Dynamic Synchronous Transfer Mode

5    (DTM) network.

## Description of related art

DTM is a broadband network architecture (see e.g.
"The DTM Gigabit Network" by Christer Bohm, Per Lindgren,

10   Lars Ramfelt and Peter Sjödin, published in Journal of
High Speed Networks, Vol. 3, No. 2, pp. 109-126, 1994,
and "Multi-gigabit networking based on DTM" by Lars
Gauffin, Lars Håkansson and Björn Pehrson, published in
Computer Networks and ISDN Systems, Vol. 24, No. 2, pp.

15   119-139, April, 1992).

DTM is a circuit switched network intended to be
used in public networks as well as in local area networks
(LAN's). It uses channels as the communication abstrac-
tion. The channels differ from telephony circuits in

20   various ways. First, the establishment delay is short so
that resources can be allocated/reallocated dynamically
as fast as user requirements change. Second, they are
simplex and so minimise overhead when the communication
is unidirectional. Third, they offer multiple bit-rates

25   to support large variations in user capacity require-
ments. Finally, they are multicast, allowing several
destinations.

DTM channels share many beneficial properties with
circuits. There is no transfer of control information

30   after channel establishment, resulting in very high
utilisation of network resources for large data trans-
fers. Support of real-time traffic is natural; there is
no need for policing, congestion control or flow control
within the network. The control information is separated

35   from data information, making the data flow swiftly

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through the network without being manipulated in network switches. The switching delay is negligible (i.e. less than 125 μs) and there is no potential for data loss because of buffer overflow as in ATM (ATM - Asynchronous

5  Transfer Mode). Bit error rates depend on the underlying media technologies, and switches are simple and fast due to strict reservation of resources at channel setup. DTM can show good performance in areas where traditional circuit-switched networks fall short: dynamic bandwidth

10  allocation, channel establishment delay, and as shared media networks.

The basic topology of a DTM network preferably comprises a bus with two unidirectional optical fibers connecting all nodes, but can also be realised by any

15  other kind of structure, e.g. a ring or hub structure. The DTM medium access protocol is a time-division multiplexing scheme. The bandwidth of the bus is divided into 125 μs cycles, which in turn are divided into 64-bit time slots. The number of slots in a cycle thus depends

20  on the network's bit-rate.

The time slots are divided into two groups, control slots and data slots. Control slots are used to carry messages for the network's internal operation. The data slots are used to transfer user data.

25  Generally, in each network node there is a node controller, which preferably controls the access to data slots and performs network management operations.

Control slots are used exclusively for messages between node controllers. Each node controller preferably

30  has write permission to at least one control slot in each cycle that it uses to broadcast control messages to other nodes. Here, broadcast refers to sending information to all downstream nodes on a bus as the transmission medium is unidirectional. Since write access to control slots is

35  exclusive, the node controller has always access to its control slots regardless of other nodes and network load.

However, if there are many nodes on the same bus, the signalling overhead represented by the control slots may constitute a large part of the total capacity. It is therefore desirable to keep the control signalling capa-

5    city as low as possible. On the other hand, the control signalling capacity determines much of the performance of the network, both for access delay and utilisation. During periods of much control signalling, it is conse- quently advantageous to have a high control signalling

10   capacity. Also, the control signalling demands vary significantly between different nodes and may also vary in time for one single node.

Summary of the invention

15       The object of the invention is to optimise the use of control slots and data slots in a network, such as a DTM network, whose bandwidth is divided into cycles, which in turn are divided into control slots for control signalling and data slots for transferring user data. It

20   is desirable to have a high bandwidth for data communica- tion and a high capacity for control signalling when requested.

         This is accomplished with a method, a controller, a node and a network according to the claims below. Hence,

25   according to the invention, there are provided means for dynamical adjustment of the control signalling capacity of a node depending on its control signaling needs.

         In the dynamic signalling concept, the signalling capacity of a node is increased by the conversion of data

30   slots into control slots, which may be called dynamic control slots, and is decreased by the conversion of control slots, preferably said dynamic control slots, into data slots.

         In a preferred embodiment, one slot per cycle or at

35   least one slot per n'th cycle (n is preferably chosen between 1 and the number of nodes on the DTM bus), called a static control slot, is left unconverted.

When data slots are converted into control slots related to a node, also all or the relevant downstream nodes may be informed about the conversion through status messages sent in the static control slot.

5    As a measure for deciding whether or not a node should convert data slots to control slots or vice versa, the length of a queue for outgoing control slots in the node may be used.

The converted slots can be used for either point-to-
10   point, multicast or broadcast signalling. This dynamic signalling concept can be combined with a slot reuse method to enable simultaneous control signalling and user data transmission in the same slot over disjointed segments of a bus or a ring.

15   Consequently, according to the invention, the problems mentioned above are avoided by dynamically optimising the control signalling bandwidth for each node.

An advantage of the invention is that it provides a
20   simple and easily implemented mechanism, which strongly improves the performance of the network, especially at lower bit rates. If at least one slot per cycle is left unconverted as a static control slot, no hardware change to the original prototype implementation is needed.

25   A further advantage of the invention is that by minimising the control signalling overhead, more nodes can be connected to each bus or ring.

Yet another advantage is that any kind of equipment can be connected to the network independently of its
30   signalling needs.

Still another advantage of the invention is that, when dynamic control slots are used for signalling to one or several other nodes, the load on rest of the nodes do not increase

35   Yet another advantage is that an improved bandwidth utilisation is achieved when combined with a slot reuse method.

Further aspects and features of the invention will
be apparent from the accompanying claims and the
description below.

5    Brief description of the drawings
Exemplifying embodiments of the invention will be
described in greater detail below with reference to
appended drawings, in which:
Fig 1 schematically illustrates a dual-bus DTM
10   network;
Fig 2 schematically illustrates a DTM 125 μs cycle
with data slots and control slots;
Fig 3 schematically illustrates n nodes sharing the
same control slot but on different cycles within the base
15   frame according to the invention;
Fig 4 schematically illustrates different signalling
channels, which define different virtual networks
according to the invention;
Fig 5 schematically illustrates a point-to-point
20   signalling channel according to the invention; and
Fig 6-9 schematically illustrates results from
simulations where dynamic signalling is included.

Detailed description of the invention
25       First, the Dynamic Synchronous Transfer Mode Medium
Access Control (DTM MAC) type of protocol will be
described with reference to Fig 1 and 2.
An example of a basic topology of a DTM network is a
bus with two unidirectional optical fibers connecting all
30   nodes, as shown in Fig 1. Several buses with different
bit-rates may be connected to form an arbitrary multi-
stage network. In the current prototype implementation,
buses can be combined into a two-dimensional mesh. A node
at the junction of two buses can synchronously switch
35   data slots between the two buses. This allows for effici-
ent switching with constant delay through the node. The

primary communication abstraction in DTM is a multi-rate, multicast channel.

The DTM medium access protocol is a time-division multiplexing scheme, as is shown in Fig 2. The bandwidth of the bus is divided into 125 µs cycles, which in turn are divided into 64-bit time slots (or slots for short). The number of slots in a cycle thus depends on the network's bit-rate; for instance, on a 6.4 Gbit/s network there are approximately 12500 slots per cycle.

In the DTM protocol, control information is separated from data. By using this kind of out-of-band control signalling, the demand for processing incoming data at high speed decreases, i.e. messages that contain control information can directly be forwarded to the protocol processing unit in the receiving node without having to process incoming data aimed for an end unit. To accomplish this, the slots are logically divided into two groups, control slots and data slots.

Control slots are are used to carry messages for the network's internal operation, such as messages for channel establishment, channel release and bandwidth reallocation. The data slots are used to transfer user data and are not interpreted by intermediate network nodes. Intermediate nodes are nodes between the source node and the destination node or nodes.

In each network node there is preferably a node controller NC, which controls the access to data slots by creating and terminating channels on demand from users. Also, the node controller NC performs network management operations, such as network start-up and error recovery, both in response to user requests and in the background.

Control slots are used exclusively for control messages between node controllers. Each node controller preferably has write permission to at least one control slot in a or each cycle, which it uses to broadcast control messages downstream to other nodes. The write access to control slots is exclusive and hence, the node

controller has always access to its control slots regardless of other nodes and network load. However, if for example a node are provided for read purposes only, it need not be neccesary to give the node write access to
5       control slots.

According to an examplifying scheme of operation, each node is initially assigned a predefined number (one or more) of control slots, called static control slots, at start-up. If there are more than one control slot
10      available to a node, its control slots may be evenly spread over the frame to get a low average access delay to control slots, since a node that shall transmit a control message must wait for a control slot to pass the node. With evenly distributed control slots the average
15      delay will be smaller.

The signalling capacity of a node is determined by the number of control slots it possesses, which normally is constant. This is, however, not always an optimal choice. For instance, if there are many nodes on the same
20      bus, the control signalling overhead represented by the control slots may constitute a large part of the total network capacity. It is therefore desirable to keep the control signalling capacity as low as possible.

On the other hand, the control signalling capacity
25      determines much of the performance of the network, both for access delay and utilisation. During periods of much control signalling, it is consequently advantageous to have a high control signalling capacity. Also, the control signalling demand varies significantly between
30      the nodes depending on the equipment attached thereto. The control signalling demand may also for one node vary in time. For instance, during day time, office equipment is active while most home equipment is inactive. During nights, the opposite is true.
35      Accordning to the inventino, it is possibile in for example a DTM network to dynamically change the control signalling capacity individually for each node, i.e. it

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is possible to change the number of control slots
assigned to each node during network operation. This is
referred to as dynamic signalling.

According to the invention, dynamic signalling
5    provides means to increase the control signalling
capacity of a node through converting data slots to
control slots and to decrease it by converting control
slots to data slots. The data slots converted to control
slots are called dynamic control slots. Preferably, but
10   not neccessarily, the static control slots are always
left unconverted.

The allocation is performed by allocating a data
slot, either a data slot already assigned to the node or
for example a data slot borrowed or overtaken from
15   another node, and mark it as control slot and then inform
all the downstream nodes on the bus about the allocating,
which is done through special status messages sent in the
node's existing control slot(s). The downstream nodes can
then start to read the allocated control slot.

20       Outgoing control messages handled by a node are
queued to be sent in a control slot. Control signalling
channel overload is recognised by, e.g. the size of the
queue for outgoing control slots. Consequently, when the
queue is long the control signalling capacity may be
25   increased and when the queue is short the control signal-
ling capacity may be decreased. The amount of slots to be
converted may also be correlated to the queue length.
Requests for conversions may also origin from the
equipment attached to the node. It is also possible for
30   example to manually initiate the conversion and decide
how many slots that are to be converted.

In the simplest implementation, the node to convert
data slots selects free data slots that it has access to.
In a more sophisticated implementation the node may
35   request and convert slots that belong to another node and
that may be situated, within the cycle, far from existing
control slots. This is done in order to decrease the

channel setup time due to lower waiting time for passing control slots.

This scheme has the disadvantage that, generally, all nodes must have access to at least one static control slot per cycle. For attaching simpler terminals to the network, one slot per cycle may introduce unnecessary overhead. For large networks with many nodes connected to each bus or when the link capacity is low, this overhead can be very high. To avoid this, a solution based on base frames has been implemented. Several cycles are then organised into base frames, each consisting of n cycles, as shown in Fig 3. The value of n is not specified, but should preferably be between 1 and the number of nodes on the bus. Then, each node preferably has access to at least one control slot per base frame and will thus have smaller control signalling capacity and longer delay for accessing but, on the other hand, the overhead is less. Dynamic control slots can then be allocated according to the invention as described above.

The slot(s) that a node possesses within the base frame is called its basic signalling channel (BSC). The n first nodes share one control slot, the n next another, etc. They share the control slot in the sense that their control slots have the same number in the cycle, but are situated in different cycles within the base frame. The capacity of the BSC's decreases and the delay to access the BSC's increases when n increases. A disadvantage with using base frames is that it requires extra hardware support since nodes need to count the cycles in a base frame. This scheme has similarities with the use of multiframes and superframes in a GSM-protocol (Group Switching Mobile protocol).

.The information sent in control messages can be of many different types. Some information is specifically directed to a set of receivers while other information is more general. For example, information for setting up a channel generally only concerns the sender, the receivers

and intermediate nodes. This type of control information
is normally most efficiently supported by point-to-point
or selected multicast channels, while more general infor-
mation, such as status information or queries for mobile
5    terminals, may be best supported by broadcast channels.
It is therefore not reasonable to broadcast all control
information to all hosts on a bus.

The dynamic signalling is taken one step further in
the virtual network concept. This concept provides means
10   to superimpose several logical structures on top of the
underlying physical infrastructure. The network can then
dynamically adapt its logical structures to for example
track changing traffic conditions. Also, many different
types of signalling needs can be foreseen: signalling
15   sent to a specific node for handling a connection, e.g.
in a client-server senario, signalling to multiple nodes
in a multicast scenario, e.g., to handle a teleconfe-
rence, and broadcast signalling that is typically used to
spread status information, e.g., routing or node state
20   information. The virtual network signalling concept
supports these different alternatives in an efficient
way.

Now referring to Fig 4, to implement the virtual
network concept, the channel abstraction, i.e., point-to-
25   point, multicast or broadcast channels, that is used for
transferring data in the DTM protocol, is also applied to
control signalling channels. The signalling messages are
thus not broadcast as in the original DTM protocol, but
are directed to one or several specific nodes. These
30   nodes will then have their own logical control signalling
channel and form a virtual network. The capacity of these
signalling channels can be dynamically changed according
to the demands of the nodes. Since the DTM channel
concept is not restricted to a single bus, a virtual
35   network may span several buses.

A node creates (or joins) a virtual network by sig-
nalling to the nodes with which it wants to communicate,

preferably by using the basic control signalling channel
(BSC). The control slot specifies which data slots will
be used for signalling within the virtual network. The
incoming slots that belong to this signalling channel
5    will be attached a local logical channel similar to the
logical channels used for data in the node. A node may
join several virtual networks and will therefore have
many different incoming and outgoing signalling channels
that are associated with different virtual networks, as
10   shown in Fig 4.

The virtual network concept further makes it possi-
ble to allocate resources strictly for the nodes attached
to the virtual network. The nodes that belong to this
network may then reallocate the slots among themselves,
15   according to the slot allocation algorithm used. It is
thus possible to use different slot allocation algorithms
for different types of traffic. The concept provides
functionality for, e.g., group communication.

Virtual networks have the largest benefits in access
20   networks, where nodes communicate sporadically. For
instance, when a video monitor is switched off or a
workstation is idle, the need for controll signalling is
very small. In that case, the node may only use the BSC.
When a workstation is used, it often communicates with
25   its server. Since the traffic from computers usually is
bursty, there is a need for more controll signalling
capacity between the workstation and the server. For this
sake, it may establish a point-to-point signalling chan-
nel to the server, as shown in Fig 5. During for example
30   a teleconferencing session, a virtual network may tempo-
rarily be created between the nodes participating in the
conference. The signalling capacity is thus allocated
according to the current demands of the involved nodes.
Nodes not attached to the virtual network are unaffected
35   by the increase in control signalling.

This concept has similarities to the signalling vir-
tual channels (SVC's) used in the Asynchronous Transfer

Mode protocol (ATM). There is one meta-signaling virtual
channel (MSVC) per interface that is permanent. Also,
there are several other types of signalling virtual
channels that are allocated between signalling end-points
5   while they are active.

The dynamic signalling concept can be combined with
a slot reuse method to further improve the bandwidth
utilisation. Nodes are connected by bus segments and
signalling channels using static or dynamic control slots
10  for point-to-point or multicast signalling use only a
subset of the segments on the bus, the remaining segments
being reserved but left unused and thus wasting shared
resources. A better alternative is to let the signalling
channels only reserve capacity on the network segments
15  between the source and the destination(s), and thus only
data slots on these segments are converted into control
slots. The data slots on the rest of the segments are
left unconverted and hence other nodes are enabled to use
these slots for data transmission or to convert them into
20  control slots for their signalling purposes. A single
slot may in this case be used multiple times on the bus,
both as a (dynamic) control slot and as a data slot. Slot
reuse enables, consequently, simultaneous signalling and
data transmission in the same slot over disjointed
25  segments of the bus.

Results from simulations will be described in the
following. The required signalling capacity depends on
the size of the transfers. Obviously, for a given load,
small transfers imply many channel creations. Instead of
30  having a large permanent signalling overhead and
dimension the signalling capacity for the worst case
situation, it is natural to dynamically adjust the number
of control slots according to the current load. In the
simulations there are an upper and lower bound for the
35  number of control slots per node. The upper bound is
there since when the amount of control slots increases
over a certain level, the NC processor is the limiting

factor in its capacity of sending control messages. The
lower bound exists to avoid that a node reallocates too
many control slots, which will result in longer channel
setup times due to waiting time for passing control
5   slots.

The amount of control slots for the node is then
adjusted by recording the access time to control slots.
If the access time exceeds the time of q frames, the
signalling capacity is increased and if the access time
10   decreases below one frame, the signalling capacity is
decreased. Practically, the access time may be measured
as the queue length for outgoing control messages. The
dynamic signalling mechanism is most important in an
access network. Also, the affect is larger in networks
15   with many nodes. Therefore, the transmission capacity,
for this simulation, is low and the number of nodes is
high. The amount of slots in the cycle is set to 1200,
which corresponds to a link capasity of 611 Gbit/s and
the network has 40x40 nodes. Some of the nodes are defi-
20   ned as hot-spots, i.e., they need a much higher signal
capacity then the rest of the nodes. Status messages that
announce allocation of control slots have higher priority
than other control messages.

In Fig 6 and in Fig 7, results are shown from the
25   simulations in terms of throughput and channel setup
versus offered load. The dynamic control slot assignment
is compared with the static case with the upper and lower
bounds assigned. The lower bound is here set to 4 slots
per cycle and the upper bound is set to 10 slots per
30   cycle. The value of q is set to 2, 4, 6 and 8 frames,
respectively.

For the upper bound the overhead from the control
slots will constitute a large part of the total amount of
slots which will reduce the throughput. However, the mean
35   access time is low. For the lower bound the queues start
to grow for higher loads and thus the channel setup time
will increase and the throughput decrease. As can be seen

from Fig 6, a slightly better performance is obtained
when q = 2. This since the response on increasing queue
length is faster and thus the channel setup time will be
low. The mechanism shall cope with long term requirements
5    for higher signalling. As can be seen in Fig 7 the
mechanism is made active for offered loads higher than
approximately 20%.

In Fig 8 and in Fig 9, the number of control slots
assigned to each node are shown at start-up after approx-
10   imately 500 μs of operation. As can be seen in Fig 9, the
amount of allocated control slots varies but many hot
spots can be recognised. In general, the nodes close to
the edges of the network will not be assigned the same
amount of control slots since upper bound limits the
15   amount of control slots for one bus. An improvement of
the scheme would be to relate the upper and lower bound
to the location on the bus or to the total amount of
control slots for a node.

The method and arrangement for dynamic signalling
20   according to the invention adjust dynamically the control
signalling bandwidth for each node to its needs. An
advantage of the invention is that it is a simple
mechanism, which strongly improve the performance of for
example a DTM network. If at least one slot per cycle is
25   left unconverted as a static control slot, no hardware
change to the prototype implementation is needed.

By minimising the signalling overhead according to
the invention, more nodes may be connected to the bus.
Any kind of equipment may be connected to the network
30   independently of its signalling needs. Combined with a
slot reuse method, the bandwidth utilisation is further
improved.

The network is not restricted to one dual-bus or
several dual-buses, but can be realised by other kind of
35   structures, e.g., ring or hub structures with an
arbitrary number of nodes. The transmission media can
besides to optical fibers be coaxial cables or any other

high bandwidth transmission media. The bandwidth of the
DTM dual bus in the preferred embodiment is divided into
125 µs cycles, which in turn are divided into 64-bit time
slots. The invention is not restricted to DTM networks
5    with these values, but can be used in networks with
cycles and slots of arbitrary sizes.

CLAIMS

1. A method for dynamic signalling in a network, having a bandwidth divided into cycles, which in turn are divided into control slots for network control signalling and data slots for transferring data, said method comprising converting data slots into control slots or converting control slots into data slots in order to change the signalling capacity of a node.

2. A method according to claim 1, wherein said data slots converted into control slots are called dynamic control slots, and wherein only said dynamic control slots may be converted into data slots.

3. A method according to claim 1 or 3, wherein said method is implemented in a Dynamic Synchronous Transfer Mode (DTM) network.

4. A method according to claim 1, 2 or 3, wherein at least one slot per cycle, called static control slot, is left unconverted when converting control slots into data slots related to said node.

5. A method according to claim 1, 2 or 3, wherein at least one slot, called static control slot, every n'th cycle is left unconverted when converting control slots into data slots related to said node, the value of n being preferably selcted as an integer value from one to the total number of nodes in said network.

6. A method according to claim 5, wherein said cycles are counted in order to localise said static control slot related to said node.

7. A method according to claim 5 or 6, wherein the respective static control slot related to different nodes

are arranged in the same position within the cycle but in
different cycles within a frame.

8. A method according to any one of the preceding
claims, further comprising informing downstream nodes
about said conversion related to said node.

9. A method according to any one of the preceding
claims, further comprising using the length of a queue
for outgoing control slots related to said node, said
queue representing the control slot demand, as a measure
for deciding whether or not data slots shall be converted
into control slots, related to said node, or vice versa.

10. A method according to any one of the preceding
claims, further comprising using the length of a queue
for outgoing control slots related to said node, said
queue representing the control slot demand, as a measure
for deciding how many data slots that shall be converted
into control slots, related to said node, or vice versa.

11. A method according to any one of the preceding
claims, further comprising selecting a data slot that
said node has access to as the slot to be converted into
a dynamic control slot related to said node.

12. A method according to any one of the preceding
claims, further comprising selecting a data slot that a
second node has access to as the slot to be converted
into a dynamic control slot related to a first node.

13. A method according to any one of the preceding
claims, further comprising using said data slots conver-
ted into control slots for point-to-point control
signalling.

14. A method according to any one of the preceding claims, further comprising using said data slots conver-ted into control slots for multicast control signalling.

5       15. A method according to any one of the preceding claims, further comprising using said data slots conver-ted into control slots for control signalling between at least two nodes on a common logical control signalling channel thus forming a virtual network.

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16. A method according to claim 15, further comprising using said dynamic control slots for allocating bandwidth to nodes attached to the virtual network.

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17. A method according to claim 15 or 16, further comprising connecting nodes on different buses to the same virtual network.

20       18. A method according to any one of claims 15-17, further comprising connecting a node to a virtual network while being connected to at least one other virtual network.

25       19. A method according to any one of the preceding claims, further comprising said method being combined with a slot reuse method in such a way that data slots are converted into control slots, or vice versa, only on segments connecting communicating nodes, a segment being
30      the part of the transmission medium that connects a node to another node, leaving the same slots on other segments of the network unconverted, and thus enabling other nodes to use these slots for data transmission or to convert them into control slots or vise versa.

35

20. A controller in a network, whose bandwidth is divided into cycles, which in turn are divided into control slots for controll signalling and data slots for transferring data, characterised by said controller being arranged to convert data slots into control slots and/or to convert control slots into data slots in order to change the signalling capacity of a node.
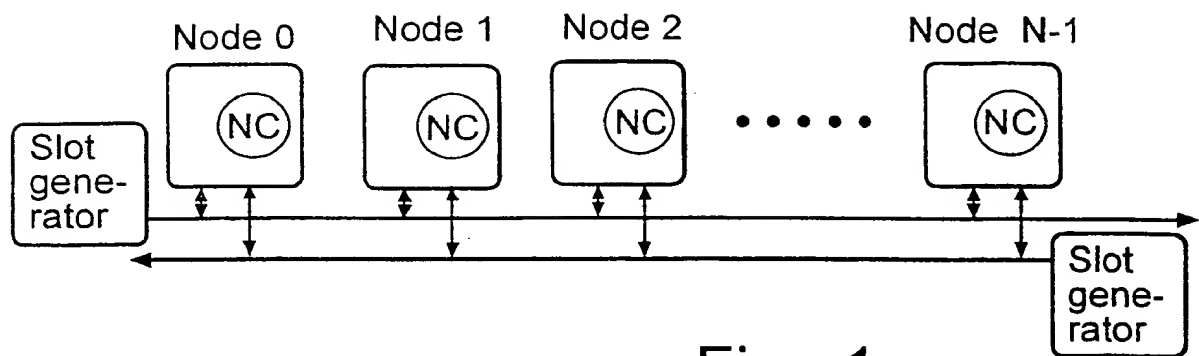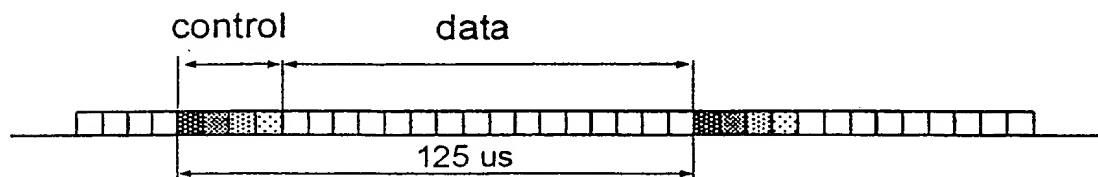
21. A controller according to claim 20, wherein said controller is located in a node of a Dynamic Synchronous Transfer Mode (DTM network.

22. A controller according to claim 20 or 21, wherein said controller is arranged to leave at least one slot per cycle or one slot per n'th cycle, called static control slot, unconverted when converting control slots into data slots related to said node.

23. A node in a  network, whose bandwidth is divided into cycles, which in turn are divided into control slots for control signalling and data slots for transferring data,  comprising a node controller, which is arranged to convert data slots into control slots and/or to convert control slots into data slots in order to change the signalling capacity of said node.

24. A network, whose bandwidth is divided into cycles, which in turn are divided into control slots for control signalling and data slots for transferring data, wherein that at least one of the nodes in said network comprises a node controller which is arranged to convert data slots into control slots and/or to convert control slots into data slots in order to change the signalling capacity of a node.

Node 0    Node 1    Node 2         Node N-1

Slot
gene-
rator

NC    NC    NC    •  •  •  •  •    NC

Slot
gene-
rator

## Fig. 1

control        data

125 us

## Fig. 2

base frame

cycle

125 µs



## Fig. 3

● = 6 signalling slot

◉ = 3 signalling slot

⊘ = 1 signalling slot

Signaling Channels

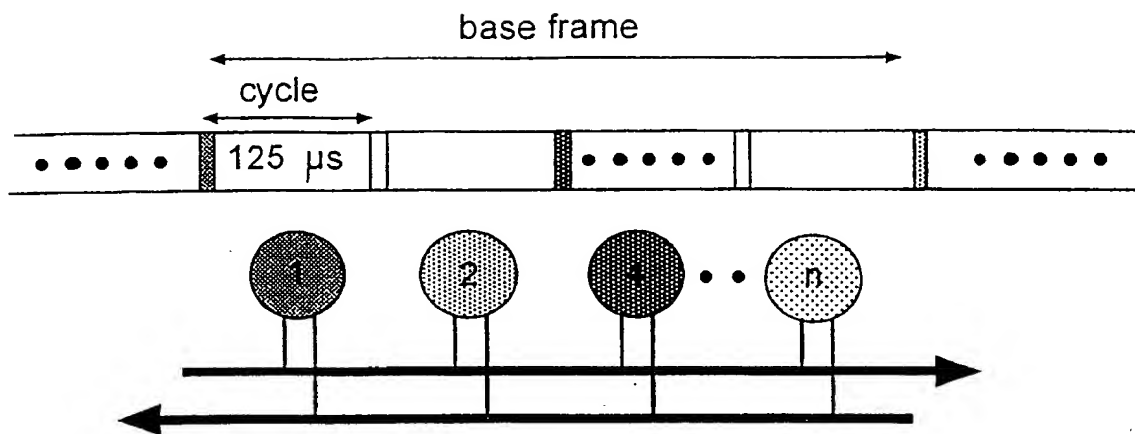Nods

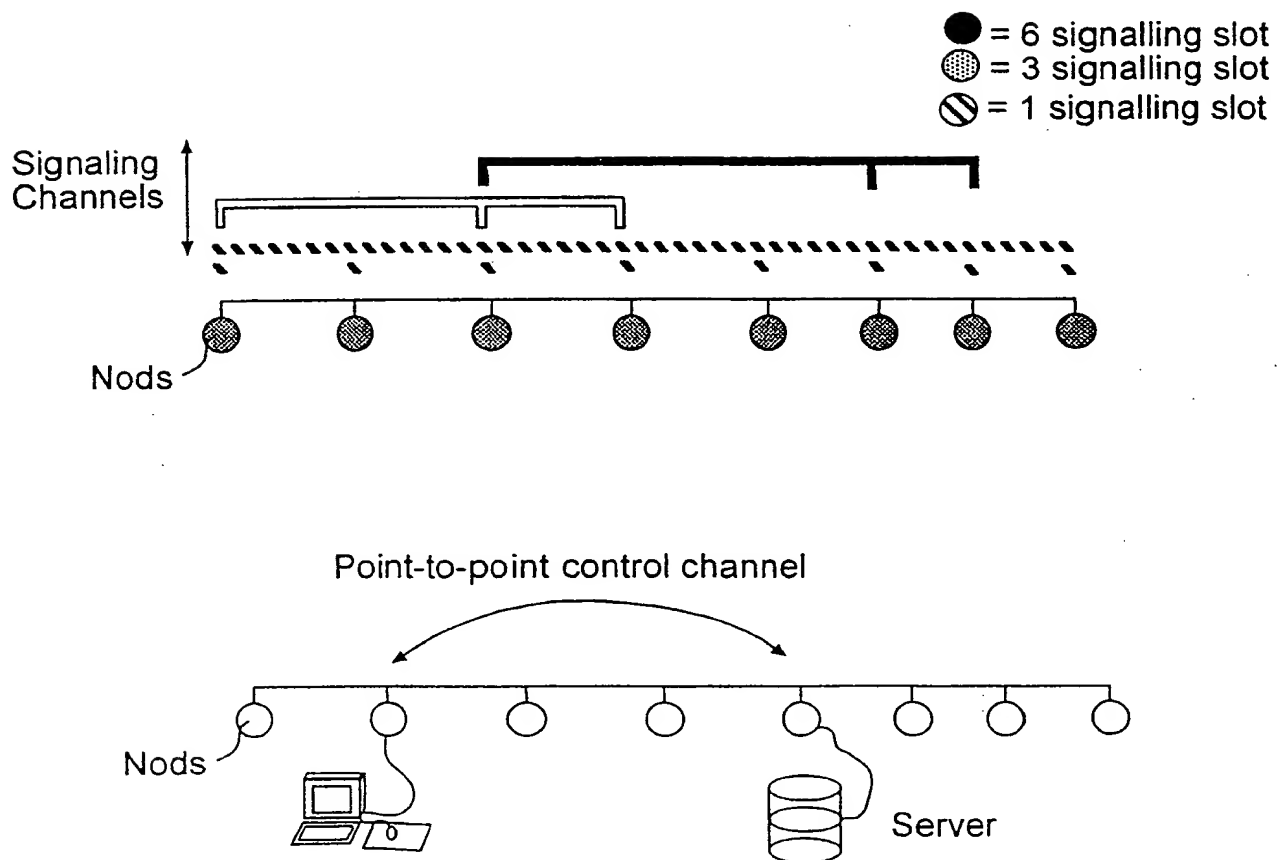Point-to-point control channel

Nods

Server

## Fig. 5

Throughput
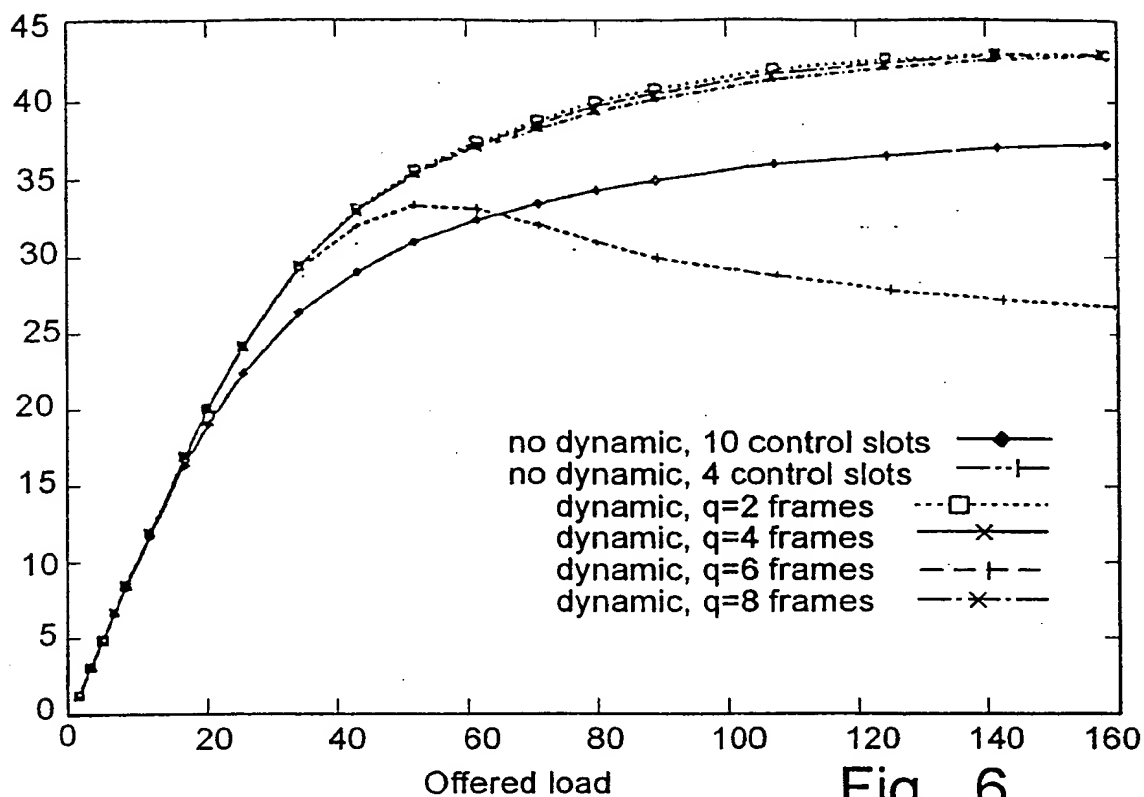


Fig. 6

Channel set-up time (microseconds)
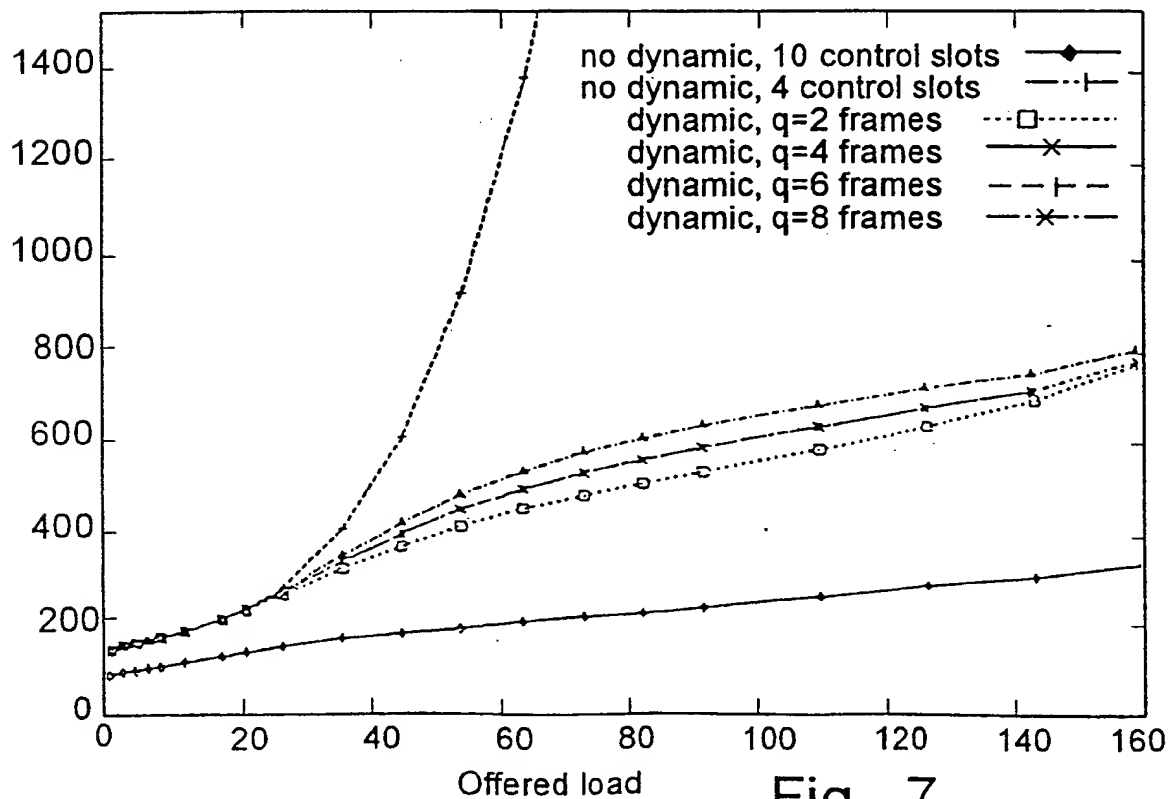


Fig. 7

**SUBSTITUTE SHEET**

Number of control slots
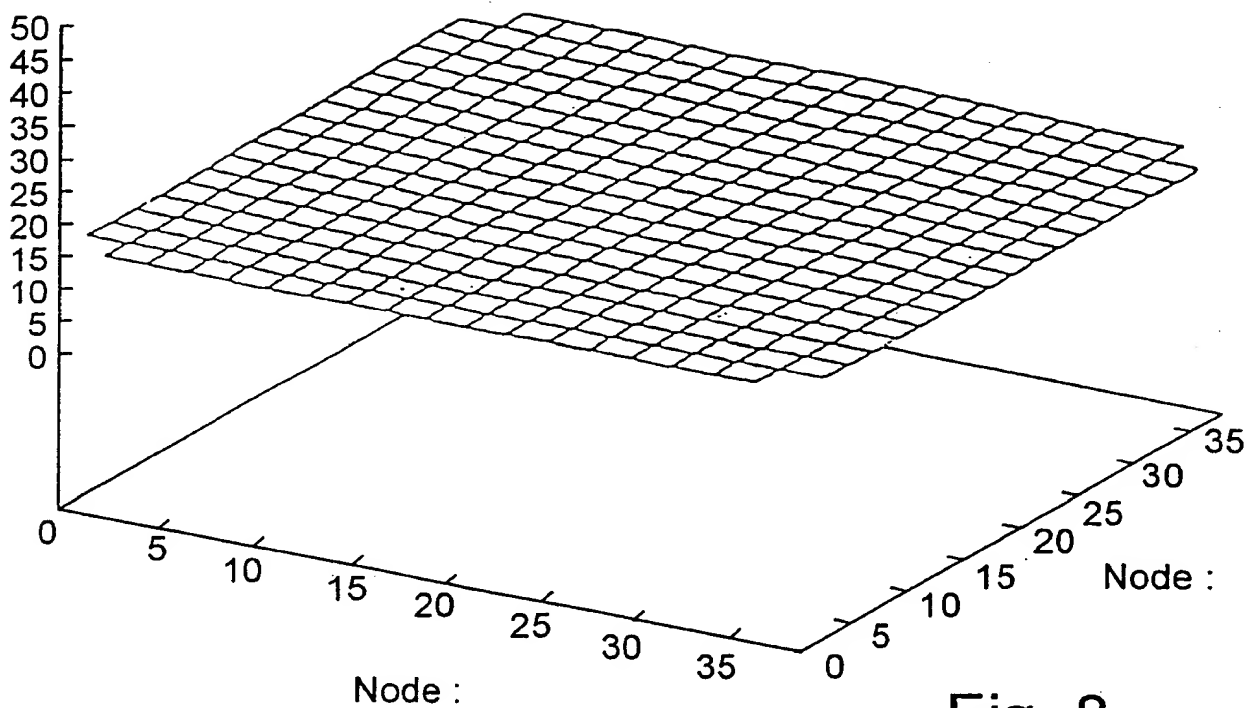


Fig. 8

Number of control slots
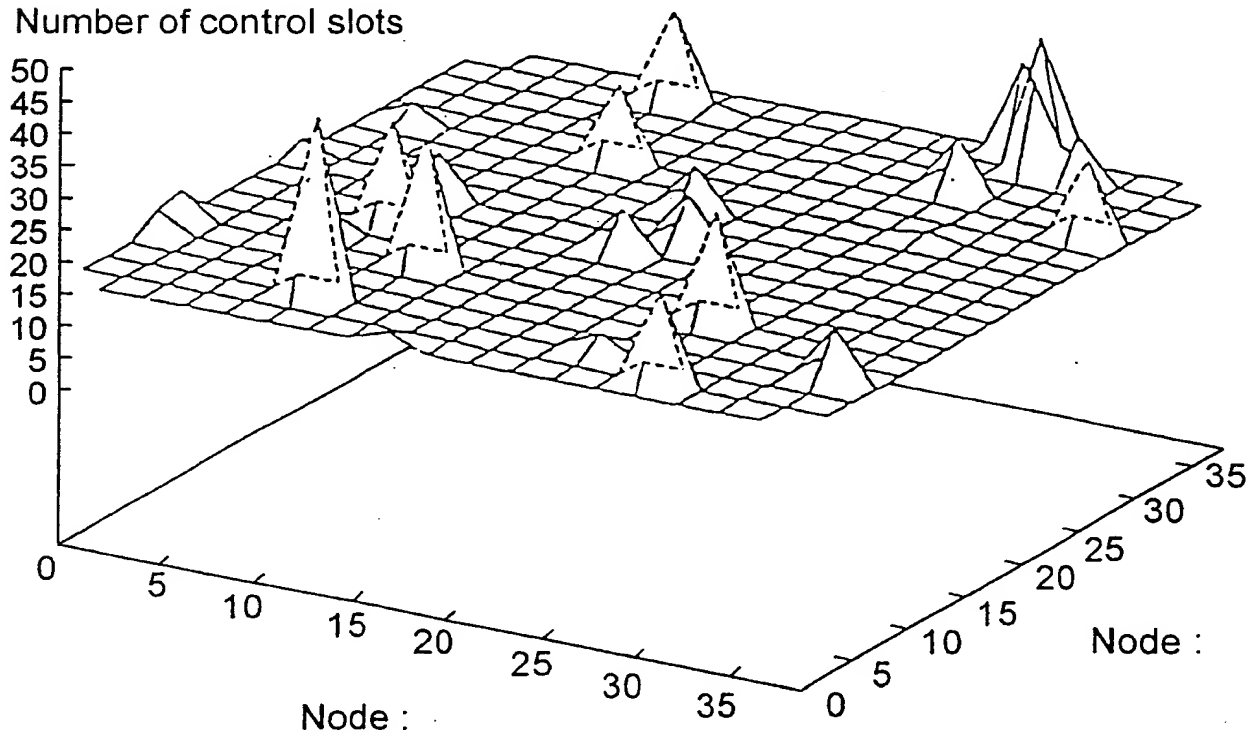
Fig. 9

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/00521

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04L 12/407, H04J 3/16

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04L, H04J, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 30 June 1997 | 0 9 -07- 1997 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86 | Anders Ströbeck Telephone No. + 46 8 782 25 00 |

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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